COMSATS University Islamabad

Registrar Office, Academic Unit (PS)

No: CUI-Reg/Notif-2409/20/2992 **December 16, 2020**

NOTIFICATION

Scheme of Studies of Doctor of Philosophy in Mechanical Engineering

It is hereby notified that the Academic Council in its 31st meeting held on October 8. 2020 approved the following Scheme of Studies of Doctor of Philosophy (PhD) in Mechanical Engineering with effect from Spring 2021 at CUI;

	Min No. of Courses	Min No. of Credit Hours
1. PhD Course Work	06	**18**
2. PhD Thesis		**09**

Note:

All the Rules and Regulation approved by BASAR/Academic Council from time to time shall be applicable

This issue with the approval of Competent Authority

Muhammad Hanif
Deputy Registrar

Distribution:

1. All Directors, CUI Campuses
2. In-charge Academics, CUI Islamabad Campus
3. In-charge, CUI Virtual Campus
4. Dean, Faculty of Engineering
5. Chairperson, Department of Mechanical Engineering
6. Controller of Examinations, CUI
7. All HoDs/Incharges of Academics/Examinations Sections, CUI, Campuses

CC:

1. PS to Rector
2. PS to Registrar

Sr #	Course Code	Course Title	Credit Hours
1.	MEE601	Product Design and Development	3(3, 0)
2.	MEE603	Control Systems	3(3, 0)
3.	MEE604	Advanced CAD/CAM	3(3,0)
4.	MEE605	Finite Element Methods	3(3, 0)
5.	MEE606	Pressurized Systems	3(3, 0)
6.	MEE608	Thin Walled Structures	3(3, 0)
7.	MEE609	Mechanism Design	3(3,0)
8.	MEE610	Joining of Materials	3(3, 0)
9.	MEE611	Expert System in Mechanical Engineering	3(3,0)
10.	MEE612	Conduction Heat Transfer	3(3, 0)
11.	MEE613	Internal Combustion Engines	3(3,0)
12.	MEE615	Robotics and Manufacturing Automation	3(3, 0)
13.	MEE616	Automation and Control	3(3, 0)
14.	MTH612	Numerical Solutions of PDEs I	3(3, 0)
15.	MTH654	Continuum Mechanics	3(3, 0)
16.	MTH661	Viscous Fluids I	3(3, 0)
17.	MTH662	Viscous Fluids II	3(3, 0)
18.	MTH664	Numerical Solutions of PDEs II	3(3, 0)
19.	MEE701	Advanced Manufacturing Systems	3(3, 0)
20.	MEE702	Advanced Thermodynamics	3(3, 0)
21.	MEE703	Advanced Dynamics	3(3, 0)
22.	MEE704	Advanced Computational Fluid Dynamics	3(3, 0)

23.	MEE705	Materials Design and Materials Processing	3(3, 0)
24.	MEE706	Modeling, Simulation and Visualization	3(3, 0)
25.	MEE707	Design Management and Prediction	3(3, 0)
26.	MEE708	Design Optimization and Analysis Techniques	3(3, 0)
27.	MEE709	Digital Manufacture and Rapid Manufacture	3(3, 0)
28.	MEE710	Advanced Laser Processing	3(3, 0)
29.	MEE711	Design of Machine Tools	3(3, 0)
30.	MEE712	Convection and Radiation Heat Transfer	3(3, 0)
31.	MEE713	Multi-Phase Flow	3(3, 0)
32.	MEE714	Advanced Topics in Mechatronics	3(3, 0)
33.	MEE715	Advanced Mechanical Vibrations	3(3, 0)
34.	MEE716	Advanced Topics in Mechanical Engineering	3(3, 0)
35.	MEE717	Engineering and Engine Tribology	3(3,0)
36.	MEE801	Modelling and Simulation of Tribological Contacts	3(3,0)
37.	MEE802	Advanced Instrumentation and Experimental Methods	3(3,0)
38.	MEE803	Advanced Engineering Material	3(3,0)
39.	MEE804	Laser Aided Manufacturing	3(3,0)
40.	MEE805	Mechatronics and Robotics Applications	3(3,0)
41.	MEE806	Mechanical Vibration and Noise	3(3,0)
42.	MEE807	Renewable Energy Conversion, Transmission and Storage Systems	3(3,0)
43.	MEE808	Finite Element Methods in Manufacturing Processes	3(3,0)
44.	MEE809	Hydrodynamic Stability	3(3,0)
45.	MEE810	Two Phase Flow	3(3,0)

46.	MEE811	Solar Energy Utilization	3(3,0)
47.	MEE812	CAD and Product Data Management	3(3,0)
48.	MEE813	Rocket Propulsions	3(3,0)
49.	MEE814	Viscous Fluid Flows and Aerodynamics	3(3,0)
50.	MEE901	Special Topics in Heat Transfer	3(3,0)
51.	MEE902	Special Topics in Applied Stress Analysis	3(3,0)
52.	MEE903	Special Topics in Fluid Mechanics	3(3,0)
53.	MEE904	Special Topics in Automation and Control	3(3,0)
54.	MEE905	Special Topics in Modeling and Simulation	3(3,0)
55.	MEE906	Special Topics in Renewable Energy Systems	3(3,0)
56.	MEE907	Special Topics in Manufacturing Systems	3(3,0)
57.	MEE908	Independent Study I	3(3,0)
58.	MEE909	Independent Study II	3(3,0)

PhD Thesis:

Sr #	Course Code	Course Title	Credit Hours
01	MEE900	Thesis	**09**

Course Code: MEE717
Course Title: Engineering and Engine Tribology
Credit Hours: 3(3, 0)
Course Objectives

1. To provide students with an understanding of how tribology fits in the overall narrative of the program.
2. Establish a fundamental understanding of tribological engineering by balancing both, theoretical and practical aspects of tribology

Course Contents

Topics to be covered will include: - Smooth/rough surfaces in contact, solid friction - Uses of Reynolds equation and Lubrication regimes - Tribological components (gears, bearings) geometry, design and parameters calculation - Lubricants: types, composition, properties, testing and specifications, condition monitoring, health, safety and environment - Damage and failure of tribological contacts - Selection of rubbing materials - Engine tribology: lubrication of components, tribological testing, advanced materials The lectures will draw on examples from applications within the automotive, marine, aerospace, oil and gas and power generation sectors. Emphasis will be placed on achieving low wear and friction and gaining sustainability and fuel efficiency through design of components and selection and condition monitoring of materials and lubricants.

Books and Reading list

- Williams, J.A., (2005). Engineering Tribology.
- R. Lewis and R.S. Dwyer-Joyce (2002). Automotive engine valve recession.
- Cameron, A (1966). Principles of Lubrication.
- Haycock R. E, Hillier J.E.,. Automotive Lubricants Reference Book.
- Taylor, C.M (1993). Engine Tribology, Tribology Series.
- Briant, J., Denis, J., Parc, G (1989). Rheological Properties of Lubricants, Chap 8.
- Mortier, R.M. and Orsulik, S.T., (1997). Chemistry and Technology of Lubricants.
- Stachowiak G.H. (2005). Engineering Tribology.
- Neale, M.J. and Gee, M (2000). Guide to wear problems and testing for industry.
- SAE, Sp-539 (1983). Studies of Engine Bearings and Lubrication.
- Zhang, X. and Changlin, G (2004). An Intelligent System for Tribology Design in Engines.
- Rahnejat, H., (2010). Tribology and dynamics of engine and powertrain:Fundamentals, applications and future trends.

Course Code: MEE801
Course Title: Modelling and Simulation of Tribological Contacts
Credit Hours: 3(3, 0)
Course Objectives

The lectures are primarily tailored for doctoral students of applied mathematics, mechanics, engineering and physics with a strong research interest in theoretical modeling, numerical simulation and experimental characterization of contact problems in technology. They are also suited for young and senior researchers in the above-mentioned and neighboring fields working in academia or in private research and development centers, interested in gaining a compact yet comprehensive overview of contact mechanics from its fundamental mathematical background, to the computational methods and the experimental techniques available for the solution of contact problems.

Course Contents

Hydrodynamic Lubrication, Computational Hydrodynamics, Hydrostatic Lubrication, Elastohydrodynamic Lubrication, Boundary and Extreme Pressure Lubrication, Solid Lubrication and Surface Treatments, Fundamentals of Contact between Solids, Abrasive, Erosive and Cavitation Wear, Adhesion and Adhesive Wear, Corrosive and Oxidative Wear, Fatigue Wear, Fretting and Minor Wear Mechanisms, Wear Of Non-Metallic Materials

Books and Reading Material

- Fluid Film Lubrication: Theory and Design by Andras Z. Szeri
- Handbook of Lubrication and Tribology by George E. Totten
- Hydrodynamic Lubrication by Hori, Yukio
- Williams, J.A., (2005). Engineering Tribology.
- R. Lewis and R.S. Dwyer-Joyce (2002). Automotive engine valve recession.
- Cameron, A (1966). Principles of Lubrication.
- Haycock R. E, Hillier J.E.,. Automotive Lubricants Reference Book.
- Taylor, C.M (1993). Engine Tribology, Tribology Series.
- Briant, J., Denis, J., Parc, G (1989). Rheological Properties of Lubricants, Chap 8.
- Mortier, R.M. and Orsulik, S.T., (1997). Chemistry and Technology of Lubricants.
- Stachowiak G.H. (2005). Engineering Tribology.
- Neale, M.J. and Gee, M (2000). Guide to wear problems and testing for industry.
- SAE, Sp-539 (1983). Studies of Engine Bearings and Lubrication.
- Zhang, X. and Changlin, G (2004). An Intelligent System for Tribology Design in Engines.
- Rahnejat, H., (2010). Tribology and dynamics of engine and powertrain:Fundamentals, applications and future trends.

Course Code: MEE802
Course Title: Advanced Instrumentation and Experimental Methods
Credit Hours: 3(3, 0)

Course Objectives

Students are given knowledge of Computational and Experimental Methods which are used in real problems of engineering disciplines.

Course Contents

Introduction to LabVIEW, Hooking the Computer up to the Real World, LabVIEW; Environment, LabVIEW Foundation, Cluster, Arrays, Structures in LabVIEW, Graphs Charts and File I/O, Getting date In and Out of Computer, DAQ and Intrument Control in LabVIEW, Functions and Structures and Communication. Transducers and Optical Techniques, Temperature, Pressure, Velocity , Species concentration, Vibration, Stress and strain, Lasers and laswer diagnostics, Computer Based data acquisition, digital I/O and counter/timers. Frequency Analysis, Frequency content of signals , Fourier Series, Fourier transform and frequency spectrum, discrete Fourier transform , Sample rate and aliasings. Digital Filtering: Transform function, first and second order. Bode plots digital filters, difference equation, discretising continuous-time filters.

Books and Reading Material:

1. Computational Methods and Experimental Measurements X, Y. Villacampa Esteve, G. M. Carlomagno and C. A. Brebbia, 2001.
2. LabVIEW for Everyone by Lisa K. Wells and Jeffrey Travis
3. Advanced LabVIEW Labs by John Essick (for DAQ Systems)

Course Code: ME 803
Course Title: Advanced Engineering Material
Credit Hours: 3(3, 0)

Course Objectives

Student will be able to choose a material for specific applications and design the product according to the material constraints.

Course Contents

History of Engineering Material, Fabrication of ODS Alloys. Fabrication of Nanophase Materials, Fabrication of Nanocomposite materials, Machanically Induced Solid State Carbonization, Induced Gas-Solid Reaction, Mechanically Induced Solid-State Amorphization. Mechanical Alloying, Mechanically Induced Solid- State Reduction,

Text Book

Mechanical Alloying for Fabrication of Advanced Engineering Material by M. Sherif El-Eskandarany, 2012

Course Code: MEE804
Course Title: Laser Aided Manufacturing
Credit Hours: 3(3,0)

Course Objectives

Laser optics, Types of Industrial Lasers, Laser Beam Parameters, Powder Metallurgy and Powder Material Characteristics, Metal Powder Characteristics. Metal Powder Compaction. Powder Injection Molding, Laser Material Interaction. Rapid Manufacturing and Laser Manufacturing. Rapid Manufacturing Processes, Heat Flow Theory, Modeling of laser processing.

Course Contents

Basic Laser optics and Working Types of Industrial Lasers, Comparisons between Lasers, Laser Parameters, Laser Beam Parameters, Polarization; Powder Metallurgy and Powder Material Characteristics: Metal Powder Treatment, Metal Powder Compaction, Powder Injection Molding. Absorption of Laser Energy, Reflectance, Absorption, Focusing of Laser Light, Laser Damage, Difference between Absorption of Solids and Powder Materials, Difference between Heat Flow in Solid and powder materials. Introduction. Selective Laser Sintering (SLS) process, Selective Laser Melting (SLM) process, Powder material properties for SLS and SLM, Types of Lasers used for SLS and SLM, Manufacturing using SLS and SLM. Introduction, Analytical Models in One Dimension, Analytical Models for Stationary Point Source, Analytical Models for Moving Heat Source, Alternative Surface Treatment Models. Modeling of laser processing of metals and polymers, Laser interaction of highly reflective metals, direct Laser Manufacturing of 3D components, Identification of laser parameters for new materials.

Text Book

- Laser Material Processing by Willian M. Steen; 2010
- Laser Processing of Engineering Materials: Principles, Procedure and Industrial Application by John C. Ion; 2011

Course Code: MEE805
Course Title: Mechatronics and Robotics Applications
Credit Hours: 3(3,0)

Course Objectives

Mechatronics is an integration of mechanical design, information technology and automatic control systems. This course introduces participants to actuators, sensors, servo control, and digital systems and how these are brought together in Mechatronics. There is also an introduction to robotics, some principles of control of servo manipulators and to other types of robots.

Course Outline:

Introduction to Mechatronics systems , AC circuits introduction , Diodes , transistors . their types and properties, Introduction to digital circuits, combinational logic and logic classes, Introduction to Boolean algebra, Introduction to sequential logic circuits and flip flops, characteristics of real Op Amps, data acquisition, D/A and A/D conversion, temperature measurement, transformers. Types uses and working of Electric Motors (stepper motors and servo motors). Overview of robots. Robot kinematics and dynamics. Control and sensing systems, robot vision Programming and interfacing. Basics of robot design and robot testing, applications of robots. Forward and Backward kinematics.

Textbooks:

Robotics, Mechatronics, and Artificial Intelligence: Experimental Circuit Blocks for Designers by Newton C. Braga; 2001

Course Code: MEE806
Course Title: Mechanical Vibration and Noise
Credit Hours: 3(3,0)

Course Objectives

The objective of the course is to enable to students to model and analyze the vibration and noise related problems of real life complex systems. At the end of the course the student will be equipped with the necessary analysis tools like. Modal analysis, and use of standard commercially available software packages to analyze and study sound and vibration.

Course Contents

Review of Vibration Fundamentals from a Practical Perspective; Structural Damping Demystified; Expanded Understanding of Vibration Isolation; The Power of Vibration Absorbers. Structure-borne Sound and High Frequency Vibration. No-Nonsense Basics of Noise and its Control. Intelligent Measurement and Analysis. Coping with Noise in Rooms. Ducts and Mufflers.

Textbooks: Mechanical Vibrations and Noise Engineering by Ambekar A. G. 2007

Course Code: MEE807
Course Title: Renewable Energy Conversion, Transmission and Storage Systems
Credit Hours: 3(3,0)

Course Objectives

Scientist and engineers working in the field renewable energy must overcome the challenges of conversion, transmission and storage before it can replace more traditional power sources such as oil and gas.

Course Contents

Strategies for the efficient conversion, transmission and storage of all forms of renewable energy. The course offer a complete background on how renewable energy is transformed into power and the best methods for transmitting and storing the energy produced. Conversion processes and storage methods for geothermal energy, biological and liquid fuels, wave energy and photovoltaic. Renewable energy conversions for powering small electrics, as well as battery applications for portable power, and energy bands in semiconductors.

Text Book:

- Renewable Energy Conversion, Transmission and Storage by Bent Sorensen: 2007
- Renewable Energy: Physics, Engineering, Environmental Impacts, Economics and Planning by Bent Sørensen; 2017

Course Code: MEE808
Course Title: Finite Element Method in Manufacturing Processes
Credit Hours: 3(3,0)

Course Objectives

The course objectives is to understand non-linear FEM and implement for simulations of high end manufacturing applications such as welding, drilling, machining etc.

Course Contents

One-dimensional material nonlinear problems, deformation in general motions, plasticity analysis, creep analysis, small deformation elasto-viscoelastic analysis, large deformation viscoelastic analysis, Application of FEM to metal forming processes. Application of FEM to metal cutting.

Books:

- Finite Element Method in Manufacturing Processes; by J. Paulo Davim; 2011
- Metal Cutting Theory and Practice by David A. Stephenson and John S. Agapiou: 2016
- Finite Element Method in Machining Processes (SpringerBriefs in Applied Sciences and Technology) by **Angelos P. Markopoulos**; 2012

Course Code: MEE809
Course Title: Hydrodynamic Stability
Credit Hours: 3(3,0)

Course Objectives

The course objectives is to understand Hydrodynamic Stability Phenomenon in the process industrial applications.

Course Contents

Introduction to hydrodynamic stability. Thermal instability. Centrifugal instability. Instability of parallel shear flows.

Books:

- Hydrodynamic Stability by Drazin; 2015
- Theory and Computation of Hydrodynamic Stability (Cambridge Monographs on Mechanics) by W. O. Criminale and T. L. Jackson; 2003

Course Code: MEE810
Course Title: Two Phase Flow
Credit Hours: 3(3,0)

Course Objectives

The objectives of the course is to understand multiphase phase phenomenon and to implement methodologies and techniques learned for design of industrial processes

Course Contents

Liquid-Solid, Liquid-vapor, Solid-gas flows, Flow regimes of liquid-vapor flows, Pressure drop predictions, Strokes flow, Drag and lift, Flow regimes of Fluidized beds and relevant statistical analysis, Bingham flow, Dispersed phase flows, Energy and momentum coupling, Reynolds transport theorem, Combustion of droplets or particles, Numerical and experimental methods

Books:

- Two-Phase Flow: Theory and Applications by Cl Kleinstreuer; 2003
- Computational Methods for Two-Phase Flow and Particle Transport; by Wen Ho Lee; 2013

Course Code: MEE811
Course Title: Solar Energy Utilization
Credit Hours: 3(3,0)

Course Objectives

Objective of course is to understand and utilization of solar energy for different applications not limited to solar heating, solar cooling, irrigation etc.

Course Contents

Advanced topics including passive, active and hybrid heating techniques, thermal storage and solar ponds, equipment in solar systems, solar distillation and evaporation, solar cooling and refrigeration, solar pumping and irrigation, high temperature applications, photovoltaic. utilization of other renewable energy resources, biomass, wind energy etc.

Books:

- Solar Energy Utilization: A Bibliographic Guide by Robert C. Liu; 2017
- Engineering Thermodynamics of Thermal Radiation: for Solar Power Utilization by Richard Petela; 2010
- Solar Energy Utilization: Fundamentals and Applications (Nato Science Series E:) by Hafit Yüncü and E. Paykoc; 2011

Course Code: **MEE812**
Course Title: **CAD and Product Data Management**
Credit Hours: **3(3,0)**

Course Objectives

This course will help students in big data management generated through 3D scanning or for manufacturing of critical parts for manufacturing codes hence providing lifecycle management.

Course Contents

Computer Aided, Design, Computer Aided Manufacturing, Computer Aided Engineering, Digital Mock-Up, Product Data Exchange, Engineering Data Management, Product Data Management, Product Lifecycle Management.

Books:

- Product Lifecycle Management (Volumes 1 and 2) (Decision Engineering) by John Stark; 2016
- Integrated Computer-Aided Design in Automotive Development: Development Processes, Geometric Fundamentals, Methods of CAD, Knowledge-Based Engineering Data Management (VDI-Buch) by Hirz Mario and Wilhelm Dietrich; 2013

Course Code: MEE813
Course Title: Rocket Propulsion
Credit Hours: 3(3, 0)

Course Objectives:

This class focuses on chemical rocket propulsion systems for launch, orbital, and interplanetary flight. It studies the modeling of solid, liquid-bipropellant, and hybrid rocket engines. Thermochemistry, prediction of specific impulse, and nozzle flows including real gas and kinetic effects will also be covered. Other topics to be covered include structural constraints, propellant feed systems, turbopumps, and combustion processes in solid, liquid, and hybrid rockets.

Course Outline:

Rocket Nozzles and Thrust, Ideal Nozzle Fluid Mechanics, Nozzle Design: Method of Characteristics, Effects of Particles in Nozzle Flow, Convective Heat Transfer: Reynolds Analogy, Convective Heat Transfer: Other Effects, Liquid Cooling, Ablative Cooling, Film Cooling, Radiation Heat Transfer and Cooling, Review of Equilibrium Thermochemistry, Examples of Chemical Equilibrium, Non-Equilibrium Flows, Selection of Propellant Mixtures, Solid Propellants: Design Goals and Constraints, Solid Propellants: Other Topics, Liquid Propellants, Combustion of Liquid Propellants, Liquid Motors: Injection and Mixing, Liquid Motors: Stability (Low Frequency), Liquid Motors: Stability (High Frequency); Acoustics, Pressurization and Pump Cycles, Basic Turbomachine Performance, Turbopumps, Turbines, Mechanical Design of Turbomachinery, Rotordynamics Problems, Dynamics of Turbopump Systems: The Shuttle Engine, Active Control of Rockets, Orbital Mechanics: Staging,

Books:

1. Sutton, George, and Oscar Biblarz. *Rocket Propulsion Elements*. New York, NY: Wiley-Interscience, 2000. ISBN: 0471326429.

Course Code: MEE814
Course Title: Viscous Fluid Flows and Aerodynamics
Credit Hours: 3(3, 0)

Course Objectives:

The major focus of this course will be on boundary layers, and boundary layer theory subject to various flow assumptions, such as compressibility, turbulence, dimensionality, and heat transfer. Parameters influencing aerodynamic flows and transition and influence of boundary layers on outer potential flow are presented, along with associated stall and drag mechanisms. Numerical solution techniques and exercises are included.

Course Outline:

Course Description. Fundamental Theorem of Kinematics - Convection, Vorticity, Strain. Eulerian vs. Langrangian Description. Convection Relations. Conservation of Mass. Conservation of Momentum. Stress Tensor. Viscosity. Newtonian Fluids. Vorticity and Circulation. Navier-Stokes Equations. Physical Parameters. Dynamic Similarity. Dimensional Analysis. Dominant Balance and Vscous Flow Classification. $Re \rightarrow \infty$ Behavior. Thin Shear Layer Equations. TSL Coordinates. Boundary Conditions. Shear Layer Categories. Local Scaling. Falkner-Skan Flows. ODE'S, PDE's, and Boundary Conditions. Well-Posedness. Numerical Methods for ODE's. Discretization. Stability. Finite Difference Methods. Newton-Raphson. Integral Methods. Integral Momentum Equation. Thwaites' Method. Integral Kinetic Energy Equation. Dissipation Methods. Integral Kinetic Energy Equation. Dissipation Methods. (cont.). Asymptotic Perturbation Theory. Higher-Order Effects. Reynolds Averaging. Prandtl's Analogy. Turbulent BL Structure: Wake, Wall Layers. Inner, Outer Variables. Effects of Roughness. (cont.) Equilibrium BL's: Clauser Hypothesis. Dissipation Formulas and Integral Closure. Equilibrium BL's: Clauser Hypothesis. Dissipation Formulas and Integral Closure. (cont.) Turbulence Modeling and Closure.

Books:

Viscos Fluid Flows, by Frank M. White; 2005